Developing an information-driven ICT framework for Agriculture

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Abstract

The ability of farmers to make informed decisions is limited by the deficiencies which have been observed in the quality and applicability of the information available to them. These deficiencies are compounded by the lack of consistent data formatting or standards for the integration of data.

Frameworks have been applied in the data mining and bioinformatics research disciplines as a means of facilitating integration of data, for example by the use of the Knowledge Discovery in Databases (KDD) methodology. This research describes a framework which has been created to assist growers in their decision making.

The Farmer Decision Support Framework (FDSF) takes information needed by farmers and utilises processes that deliver this critical information. A series of steps which include data capture, analysis and data processing precede the delivery of integrated information to the farmer. Information is collected from disparate sources, captured and validated according to defined rules. It is then processed and integrated by data mining tools and technologies into a format that can be readily used by the farmer.

This research paper describes the results of a case study of the proposed framework and the use of simulated data to identify any critical bottlenecks in the application of the framework. It will also speculate on ways in which the framework may be extended to be used in all farmer decision-making processes.

Keywords: decision making, cropping, information process, farmer

Introduction

The delivery of information to Western Australian farmers is vital if they are to improve farm practices, adopt new technologies and varieties and respond to the ever demanding pressures caused by changes in environmental conditions and the global economy. Previous research has suggested that the quality of the information presented to the grower and the subsequent skills required by the grower to interpret the information, have a large impact on the adoption of new farming practices and varieties. (Armstrong et al. 2007). This is supported by Umber (2006) who reported that for information to be effectively used by growers, it needs to be delivered in a format that can be easily integrated into grower decision making.

The research area of decision making theory initially provided frameworks that suggested that the process of making a decision was a series of sequential steps; identify the problem, generate alternative solutions, evaluate and choose, implement (McKenna and Martin-Smith 2005). However, more recently, these ideas have been replaced by a more complex chaotic cycle based decision making process (McKenna and Martin-Smith 2005). A number of attempts have been made to develop systems which deliver customizable information to growers to assist in their decision making in terms of crop choices. For example, Reddy and Ankaiah (2005) proposed a cost effective agricultural information dissemination system (AgriIDS) which aimed to deliver location specific expert agricultural knowledge to farming communities in India. Similarly, research by Ratnam, Krishan Readdy and Reddy (2005) has described how customized information is disseminated to farmers using a web based expert system (eSagu). A further example of a farm-level modelling framework for the support of farmer decision making processes has been reported by del Prado and Scholefied (2008).

The adoption of new technologies and practices in agriculture has been studied extensively. The decision to adopt new technologies is dependent on social, demographic, political, technological and economic factors and is "inherently multivariate" (Dorfman 1996, Isgin et al. 2008). Conley and Udry (2001) proposed that the adoption of new farm practices and the solutions to the problems faced by individual growers taking up new technologies is dependent on social learning through networking with other growers. Furthermore, the adoption of new practices has also shown to be dependent on factors such as farmer education level, the availability of adequate information and farmer perceptions (Traore, Landry and Amara 1998).

This research aims to quantify the processes involved in a grower seeking information and making decisions about farming practices to be employed during the season. Other attempts to help growers manage the increasing amounts of information needed to manage and run their operations in the most effective and efficient manner have been reported in the Australian rice industry (Graham et al 2002).

This paper will develop an information-based decision framework for growers. The framework will be based on a common scenario of a grower seeking cropping information in order to increase crop yield. While some research has attempted to develop agricultural information dissemination frameworks such as the AgriIDS framework developed by Reddy and Ankaiah (2005), it is evident that further work is needed to elaborate the process in relation to different growers in various scenarios.

Background

The Western Australian cereal industry is large scale, export-oriented and profit driven. Farmers are reliant on high technology farm machinery and frequently delivering high yielding varieties for specialized quality markets. As a consequence, farmers rely on accurate location and farming-specific information to assist decision making for all aspects of their cropping, e.g. choosing varieties, herbicide spraying and fertilizer application.

The delivery of cropping information in the Western Australian agriculture sector is through government and private consultants. This information is provided from various sources including paper-based publications, websites, agricultural advisors and other farmers. Farmers value the customized information on crop performance provided for their local situation. Such information is provided at demonstration and research trials or by local farmer growing a new variety in their paddock. However, acquiring this information and then distributing it locally is often a challenge: field days and agricultural advisors are the preferred methods of delivery. Consequently, information websites are being established by breeding and seed companies with information about available crop varieties, enabling growers to access this information. The state government's Department of Agriculture and Food (DAFWA) provides Western Australian growers with a website which offers downloadable reports and the ability to compare varieties.

More recently, DAFWA has provided decision-aid systems which allow farmers to ask “what-if" questions for these recommended varieties to enable them to make more informed decisions. This "what-if" information has been delivered for several years by DAFWA via downloaded Microsoft Excel program that runs on the grower’s computer (DAFWA 2007). The problem with this method of delivery is the program needs to be downloaded regularly with the latest information to ensure the latest variety comparison information is included.

Anecdotal evidence would suggest that farmers vary in their approach to seeking information and adopting of new technologies. Traditional growers usually seek information from standardized crop variety publications which are provided free to each grower. These growers also seek information from agricultural advisors and through organized field days and have limited skill sets in retrieving information using internet and other technologies. With the greater penetration of the Internet into country areas, innovative growers are using computers much more to seek information and conduct their businesses.

Methodology

This research draws on knowledge gained of the practices used by agricultural scientists, extension officers, agricultural consultants and Western Australian growers in the production, delivery and use of cropping based information. The authors have many years of professional practice in the area of crop variety testing and plant breeding research. The Farmer Decision Support Framework (FDSF) was created using Unified **M**odelling **L**anguage (Object Management Group 2008) and is an industry standard system modelling framework used frequently in the analysis and design of software systems.

The FDSF was developed using two commonly used modelling diagrams, the user case scenario diagram and the sequence diagram. Initial modelling of the decision making process formulated a simple inputs, process, and outputs model in order to describe the information flow process model. This was further refined for a specific scenario based on “A farmer wanting to improve his crop yield”. The model framework was further refined to provide alternative decision- making processes and includes the ability to cycle through decisions. Once the initial models were defined, a use case diagram was used to outline the framework. The final stage in the development of the framework was to use sequence diagrams to map the information flow and decision making process for individual scenarios.

Farmer Decision Support Framework

The FDSF can be considered to be a general information flow framework which takes inputs, processes and collates these inputs and outputs as a decipherable data set. The framework comprises a series of steps which include data capture, analysis and data processing and which precede the delivery of integrated information to the farmer. Information is collected from disparate sources, collated and validated according to defined rules. It is then processed and further integrated, by using data mining tools and other technologies, into a format that may be readily used by the farmer.

The Farmer Decision Support Framework (FDSF) has been proposed in order to explain the general flow of crop related information from the perspective of the farmer. The framework can be used to identify the data types and granularity needed and where they will be used in the process. It is designed to identify, at an abstract industry level, where researchers and information generators can best support the delivery of cropping information with the view to improving farmer decision making. The ultimate goals of developing this framework were firstly to see how new technologies, such as the use of the Internet and data mining techniques, can fit into the process; and secondly to identify the information problems and bottlenecks and find solutions to alleviate these bottlenecks.

Three types of participants are central to the information provision process; they are information generators, facilitators and users. Information generators make available the information to the information facilitators who receive, filter and process the information in a customizable format for the information users. An elaboration of the type's participants and information in the system are outlined below in Table 1 and 2.

Table 1 Types of information participants

Type	Description
User	Farmers, farm groups, general public, consultants, industry groups
Facilitator	Consultants, agricultural scientists, extension officers, seed company representatives
Generator	Private research organizations, government agencies, farmer groups, seed companies

Table 2 Inputs, process and outputs in the system

Stage	Description	Example
Inputs	Get general information	Publications, library, Internet sites, other farmers, field trial days
Process	Search, collate, analyse, filter and customize information	Internet searches, expert systems, decision aids, statistical analysis, data mining
Outputs	Report customized information	Crop variety guides, farm bulletins, Internet sites, farm manuals, ready reckoners

The information flow process used to develop the generic Farmer Decision Support Framework is shown in Figure 1. The use case diagram displayed in Figure 2 was used to illustrate the system from a farmer's perspective, outlining the actors and the use cases that describe the general processes in the system. This process is *Get Advice*, *Filter Information*, *Customize Information*, *Make Decision*, *Implement Decision*, and *Validate and Review Decision*.

The FDSF may also be used to show how information flow and decision making varies for different farmers and situations. The use of UML sequence diagrams allows a close examination of the information process and the interaction between the participants in the system. An example is demonstrated in Figure 3, which highlights differences in the approach of two types of farmers, traditional farmers and innovative farmers. Traditional farmers can be characterized as those that prefer to use printed materials such as the Crop Variety Sowing guides and have limited skills in the use of the Internet, or are limited by access to the Internet. These farmers also prefer to have face-to-face contact with other growers and agricultural consultants. Innovative farmers are characterized as being willing to collate their own information multiple sources and formats. They are skilled in searching the Internet and will seek advice using expert systems and other decision aids.

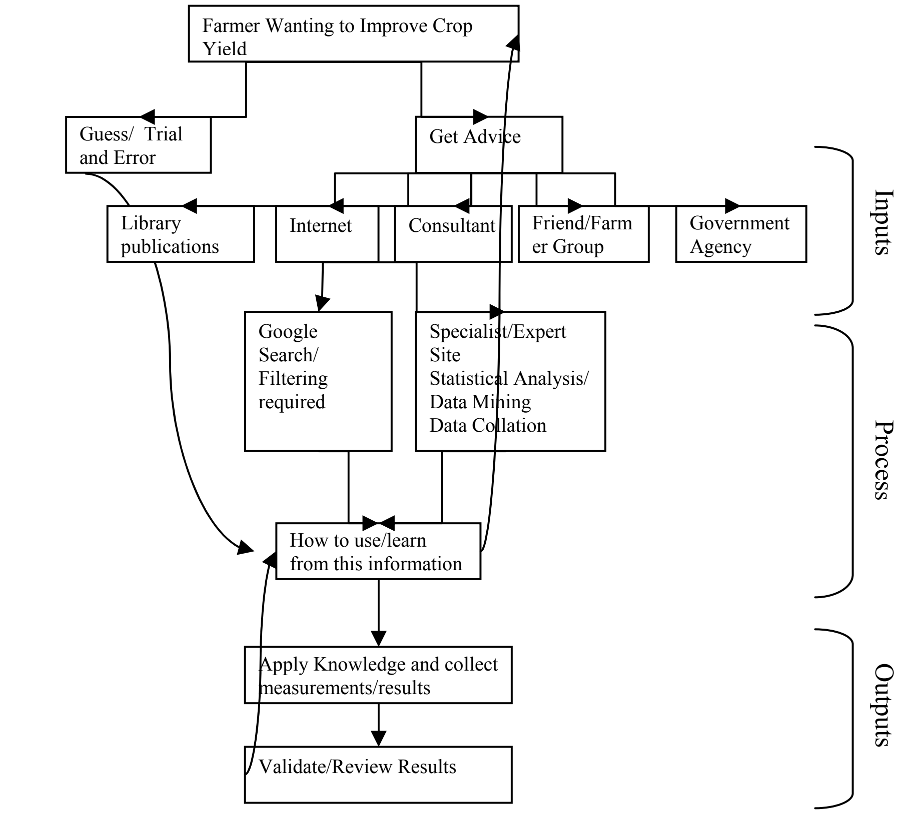

Figure 1 Farmer information flow process

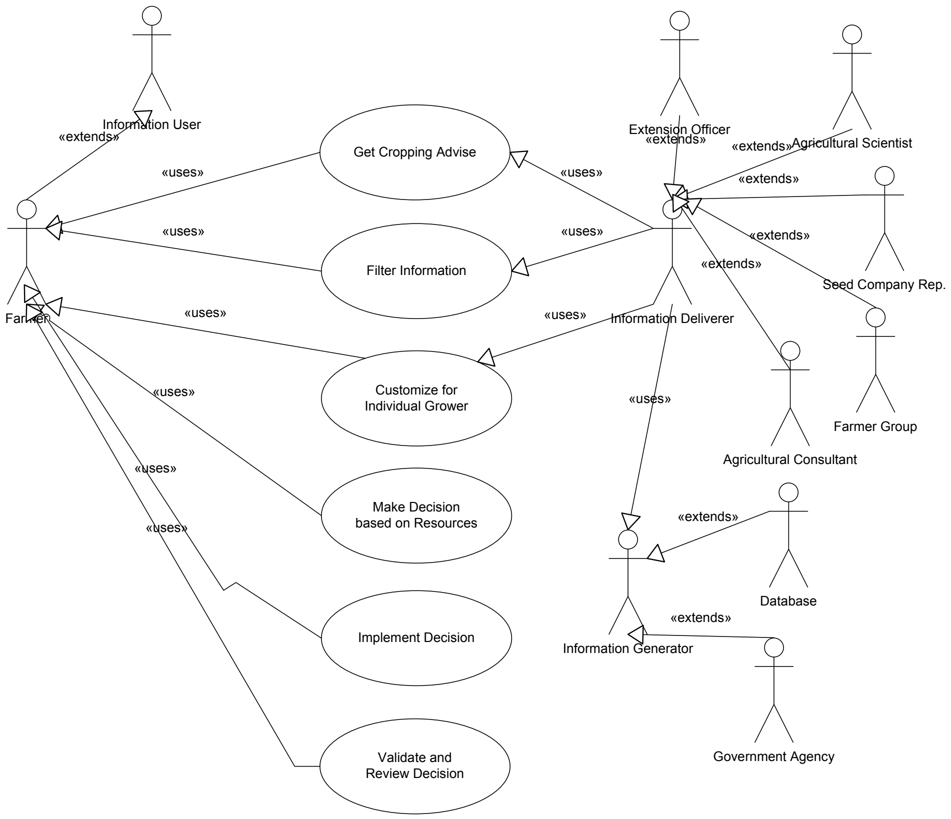

Figure 2 Farmer decision process use case diagram

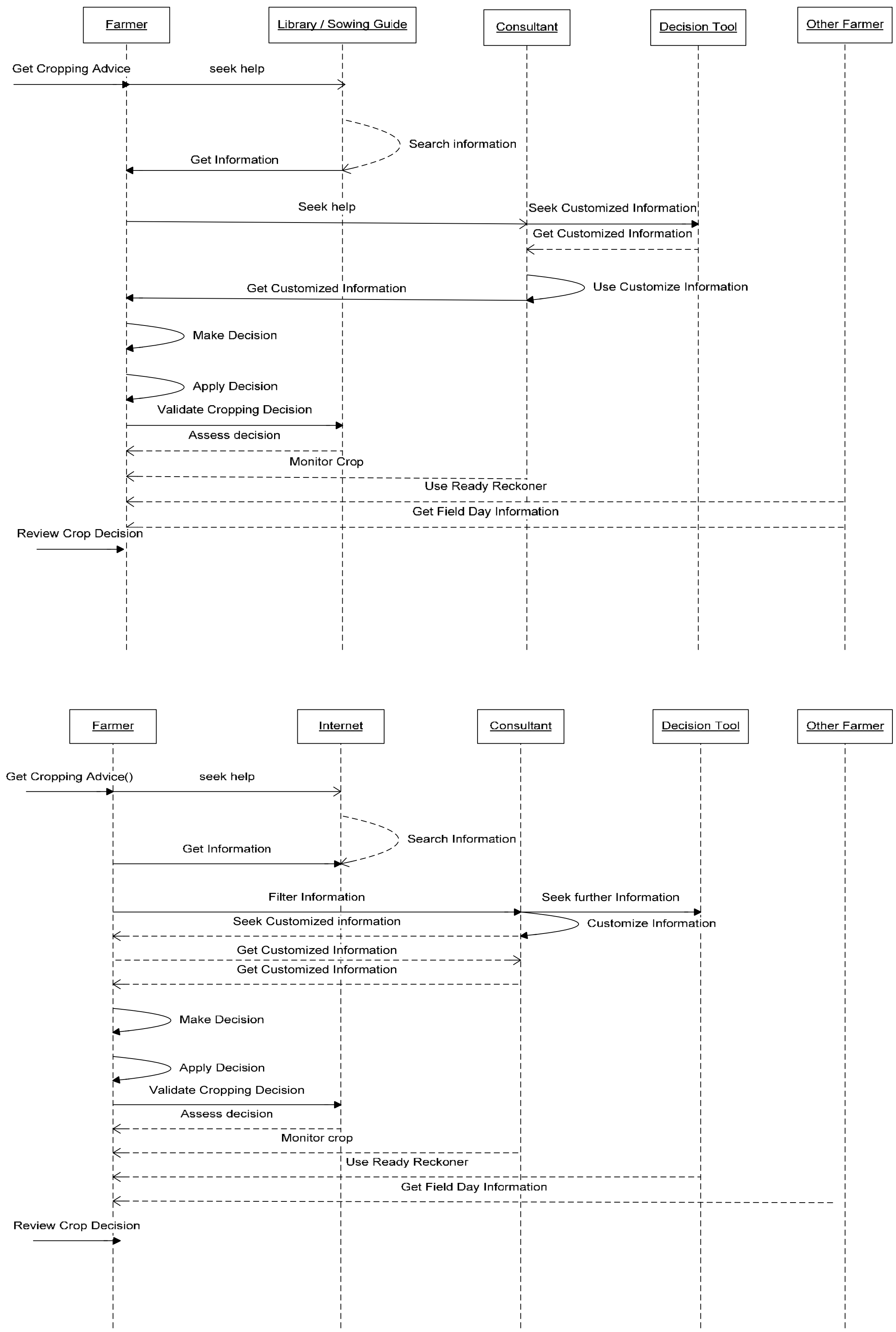

Figure 3 (a) Traditional and (b) Innovative farmers' crop variety decision process.

A comparison approaches found that the traditional farmer approach took few information seeking steps and relied on help from recipe-based publications and consultants to make decisions. This information is likely to be generalized and not necessarily customized. The innovative farmers make greater individual efforts and skills to perform their own initial searches. Any interaction with the consultants adds to the complexity of the process. Moreover this refinement leads to greater customization of information. Examination of the sequence diagrams shows it is possible to establish where information flow and decision-making processes might break down and/or result in inaccurate information being provided to the farmer.

Discussion

Farmers must be able to make informed decisions in order to improve their farming practices if their businesses are going to remain profitable. In order to understand how this process can be improved, there is a need to elaborate the information flow and decision making processes. The proposed FDSF provides a mechanism for agricultural scientists and extension specialists map all aspects of the information flow process accurately and decide where there is a need to concentrate efforts to assist in farmer decision making. At a higher industry level, it could be used to improve the likelihood of farmers receiving the most appropriate information to make valued decision.

The benefit of using such a framework is that it may be applied to specific scenarios and decision making. In addition, it may be used as a supportive tool and to establish where new technologies, such as the use of Internet and data mining can fit into the process. In the example scenarios provided in this paper, the framework was effectively tailored for Western Australian growing conditions and farmer practices. The framework might easily be applied to other agricultural decision making processes such as animal husbandry or pasture management. It is envisioned that this framework could be used as a basis for the development of an online farm management system that could provide structured support for researchers and extension specialists to assist farmers in their decision making.

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